

## CHAPTER 8

# The Costs of Production

Previous chapters discussed consumer behavior and product demand. This chapter switches to producer behavior and business firms. It explains how a firm's **costs of production** change as the firm's output changes, in the short run and in the long run.

This chapter begins with a definition of cost and profit. You should be somewhat familiar with these terms because they were first introduced in Chapters 1 and 2. The explanation is now more detailed. Several definitions of cost and profit are given in the chapter, so you must know the distinctions if you are to understand the true meaning of **economic cost** and **economic profit**.

The second and third sections of the chapter focus on **short-run** variable relationships and production costs for the firm. You are first introduced to the important **law of diminishing returns**, which defines the relationship between the quantity of resources used by the firm and the output the firm produces in the short run. The chapter discussion then shifts to costs because resource prices are associated with the fixed and variable resources the typical firm uses to produce its output. The three basic types of short-run costs—total, average, and marginal—vary for the firm as the quantity of resources and output changes. The chapter describes the relationship among the various cost curves and how they are shaped by the law of diminishing returns.

The fourth section of the chapter looks at production costs in the **long run**. All resources, and also production costs, are variable in the long run. You will learn that the long-run cost curve for the typical firm is based on the short-run cost curves for firms of different sizes. In the long run, firms can experience **economies of scale** and **diseconomies of scale** that will shape the long-run cost curve for the firm. The chapter concludes with several practical applications of the concept of scale economies.

It is important that you master this material on the costs of production because it sets the foundation for understanding the price and output decisions of a firm operating under different market structures that you will be reading about in the next three chapters.

### ■ CHECKLIST

When you have studied this chapter you should be able to

- ☐ Define economic cost in terms of opportunity cost.
- ☐ Distinguish between an explicit cost and an implicit cost.
- ☐ Explain the difference between normal profit and economic profit.

- ☐ Distinguish between the short run and the long run in production.
- ☐ Define total product, marginal product, and average product.
- ☐ State the law of diminishing returns and explain its rationale.
- ☐ Compute marginal product and average product to illustrate the law of diminishing returns when you are given the necessary data.
- ☐ Describe the relationship between marginal product and average product.
- ☐ Define fixed costs, variable costs, and total cost.
- ☐ Define average fixed cost, average variable cost, and average total cost.
- ☐ Explain how average product is related to average variable cost.
- ☐ Define marginal cost.
- ☐ Explain how marginal product is related to marginal cost.
- ☐ Compute and graph average fixed cost, average variable cost, average total cost, and marginal cost when given total-cost data.
- ☐ Describe the relation of marginal cost to average variable cost and average total cost.
- ☐ Explain why short-run cost curves shift.
- ☐ Illustrate the difference between short-run average total cost curves for a firm at different outputs and its long-run average total cost curve.
- ☐ Describe various possible long-run average total cost curves.
- ☐ Define and list reasons for the economies and diseconomies of scale.
- ☐ Explain the concept of minimum efficient scale and its relation to industry structure.
- ☐ Give examples of short-run costs, economies of scale, and minimum efficient scale in the real world.
- ☐ Explain why sunk costs are irrelevant in decision-making (Last Word).

### ■ CHAPTER OUTLINE

1. Resources are scarce and are used to produce many different products. The **economic cost** of using resources to produce a product is an opportunity cost: the value or worth of the resources in its best alternative use.
  - a. Economic costs can be explicit or implicit. **Explicit costs** are the monetary payments that a firm makes to obtain resources from nonowners of the

firm. **Implicit costs** are the monetary payments that would have been paid for self-owned or self-employed resources if they had been used in their next best alternative outside the firm.

**b. Normal profit** is an implicit cost and is the minimum payment that entrepreneurs must receive for performing the entrepreneurial functions for the firm.

**c. Economic, or pure, profit** is the revenue a firm receives in excess of all its explicit and implicit economic (opportunity) costs. (The firm's accounting profit is its revenue less only its explicit costs.)

**d.** A distinction is made between the **short run** and the **long run**. The firm's economic costs vary as the firm's output changes. These costs depend on whether the firm is able to make short-run or long-run changes in its resource use. In the short run, the firm's plant is a fixed resource, but in the long run it is a variable resource. So, in the short run the firm cannot change the size of its plant and can vary its output only by changing the quantities of the variable resources it employs.

2. There are **short-run** relationships between inputs and outputs in the production process.

**a.** Several product terms need to be defined to show these relationships. **Total product (TP)** is the total quantity of output produced. **Marginal product (MP)** is the change made in total product from a change in a variable resource input. **Average product (AP)**, or productivity, is the total product per unit of resource input.

**b.** The **law of diminishing returns** determines the manner in which the costs of the firm change as it changes its output in the short run. As more units of a variable resource are added to a fixed resource, beyond some point the marginal product from each additional unit of a variable resource will decline.

(1) There are three phases reflected in a graph of the total product and marginal product curves: increasing, decreasing, and negative marginal returns.

(2) When total product is increasing at an increasing rate, marginal product is rising; when total product is increasing at a decreasing rate, marginal product is falling; and when total product declines, marginal product is negative.

(3) When marginal product is greater than average product, average product rises, and when marginal product is less than average product, average product falls.

3. When input, output, and price information is available, it is possible to calculate **short-run production costs**.

**a.** The **total cost** is the sum of the firm's fixed costs and variable costs. As output increases,

(1) **fixed costs** do not change;

(2) at first, the **variable costs** increase at a decreasing rate, and then increase at an increasing rate;

(3) and at first total costs increase at a decreasing rate and then increase at an increasing rate.

**b.** **Average costs** consist of **average fixed costs (AFC)**, **average variable costs (AVC)**, and **average total costs (ATC)**. They are equal, respectively, to the

firm's fixed, variable, and total costs divided by its output. As output increases

(1) average fixed cost decreases

(2) at first, average variable cost decreases and then increases

(3) and at first, average total cost also decreases and then increases

**c. Marginal cost (MC)** is the extra cost incurred in producing one additional unit of output.

(1) Because the marginal product of the variable resource increases and then decreases (as more of the variable resource is employed to increase output), marginal cost decreases and then increases as output increases.

(2) At the output at which average variable cost is a minimum, average variable cost and marginal cost are equal, and at the output at which average total cost is a minimum, average total cost and marginal cost are equal.

(3) On a graph, marginal cost will always intersect average variable cost at its minimum point and marginal cost will always intersect average total cost at its minimum point. These intersections will always have marginal cost approaching average variable cost and average total cost from below.

**d.** Changes in either resource prices or technology will cause the cost curves to shift.

4. In the long run, all the resources employed by the firm are variable resources. **Long-run production costs** are all variable costs.

**a.** As the firm expands its output by increasing the size of its plant, average total cost tends to fall at first because of the **economies of scale**, but as this expansion continues, sooner or later, average total cost begins to rise because of the **diseconomies of scale**.

**b.** The long-run average total cost curve shows the least average total cost at which any output can be produced after the firm has had time to make all changes in its plant size. Graphically, it is made up of all the points of tangency of the unlimited number of short-run average total cost curves.

**c.** The economies and diseconomies of scale encountered in the production of different goods are important factors influencing the structure and competitiveness of various industries.

(1) **Economies of scale** (a decline in long-run average total costs) arise because of labor specialization, managerial specialization, efficient capital, and other factors such as spreading the start-up, advertising, or development costs over an increasing level of output.

(2) **Diseconomies of scale** arise primarily from the problems of efficiently managing and coordinating the firm's operations as it becomes a large-scale producer.

(3) **Constant returns to scale** are the range of output where long-run average total cost does not change.

**d.** Economies and diseconomies of scale can determine the structure in an industry. **Minimum efficient scale (MES)** is the smallest level of output at which a firm can minimize long-run average costs. This concept

explains why relatively large and small firms could co-exist in an industry and be viable when there is an extended range of constant returns to scale.

(1) In some industries the long-run average cost curve will decline over a range of output. Given consumer demand, efficient production will be achieved only with a small number of large firms.

(2) If economies of scale extend beyond the market size, the conditions for a **natural monopoly** are produced, which is a rare situation where unit costs are minimized by having a single firm produce a product.

(3) If there are few economies of scale, then there is minimum efficient size at a low level of output and there are many firms in an industry.

5. There are several applications and illustrations of short-run costs, economies of scale, and minimum efficient cost.

a. A rise in the cost of corn raises short-run cost curves (AVC, MC, ATC) for businesses that use corn as a product input.

b. Economies of scale can be seen in successful start-up firms such as Intel, Microsoft, or Starbucks. Economies of scale are also exhibited in the Verson stamping machine that makes millions of auto parts per year.

c. A small price can be charged for a newspaper because the fixed costs are spread across a large amount of output, thus achieving economies of scale.

d. Economies of scale are extensive in aircraft production, but modest in concrete mixing, which achieves minimum efficient scale at a low level of output. As a consequence, there are few aircraft factories and many concrete mixing companies.

6. (Last Word). Sunk costs are irrelevant to economic decision making because they are already incurred and cannot be recovered. Sunk costs are the result of making a past decision, not a current decision. A current decision is made on the basis of evaluating marginal costs and marginal benefits. If the marginal costs are less than the marginal benefits, the action will be taken.

#### ■ HINTS AND TIPS

1. Many **cost** terms are described in this chapter. Make yourself a glossary so that you can distinguish among them. You need to know what each one means if you are to master the material in the chapter. If you try to learn them in the order in which you encounter them, you will have little difficulty because the later terms build on the earlier ones.

2. Make sure you know the difference between **marginal** and **average** relationships in this chapter. Marginal product (MP) shows the *change* in total output associated with each additional input. Average product (AP) is simply the output per unit of resource input. Marginal cost (MC) shows the change in total cost associated with producing another unit of output. Average cost shows the per-unit cost of producing a level of output.

3. Practice drawing the different sets of **cost curves** used in this chapter: (1) short-run total cost curves, (2) short-run average and marginal cost curves, and (3) long-run cost curves. Also, explain to yourself the relationship between the curves in each set that you draw.

4. In addition to learning *how* the costs of the firm vary as its output varies, be sure to understand *why* the costs vary the way they do. In this connection note that the behavior of short-run costs is the result of the law of diminishing returns and that the behavior of long-run costs is the consequence of economies and diseconomies of scale.

#### ■ IMPORTANT TERMS

economic (opportunity) cost

explicit costs

implicit costs

normal profit

economic profit

short run

long run

total product (TP)

marginal product (MP)

average product (AP)

law of diminishing returns

fixed costs

variable costs

total cost (TC)

average fixed cost (AFC)

average variable cost (AVC)

average total cost (ATC)

marginal cost (MC)

economies of scale

diseconomies of scale

constant returns to scale

minimum efficient scale (MES)

natural monopoly

#### SELF-TEST

#### ■ FILL-IN QUESTIONS

1. The value or worth of any resource in its best alternative use is called the (out-of-pocket, opportunity)

\_\_\_\_\_ cost of that resource.

2. The economic cost of producing a product is the amount of money or income the firm must pay or provide

to (government, resource suppliers) \_\_\_\_\_ to attract land, labor, and capital goods away from alternative uses in the economy. The monetary payments, or out-

of-pocket payments, are (explicit, implicit) \_\_\_\_\_ costs, and the costs of self-owned or self-employed resources are \_\_\_\_\_ costs.

3. Normal profit is a cost because it is the payment that the firm must make to obtain the services of the (workers, entrepreneurs) \_\_\_\_\_. Accounting profit is equal to the firm's total revenue less its (explicit, implicit)

\_\_\_\_\_ costs. Economic profit is not a cost and is equal to the firm's total (costs, revenues) \_\_\_\_\_ less its economic \_\_\_\_\_.

4. In the short run the firm can change its output by changing the quantity of the (fixed, variable) \_\_\_\_\_ resources it employs, but it cannot change the quantity of the \_\_\_\_\_ resources. This means that the firm's plant capacity is fixed in the (short, long) \_\_\_\_\_ run and variable in the \_\_\_\_\_ run.
5. The law of diminishing returns is that as successive units of a (fixed, variable) \_\_\_\_\_ resource are added to a \_\_\_\_\_ resource, beyond some point the (total, marginal) \_\_\_\_\_ product of the former resource will decrease. The law assumes that all units of input are of (equal, unequal) \_\_\_\_\_ quality.
6. If the total product increases at an increasing rate, the marginal product is (rising, falling) \_\_\_\_\_. If it increases at a decreasing rate, the marginal product is (positive, negative, zero) \_\_\_\_\_, but (rising, falling) \_\_\_\_\_.
7. If total product is at a maximum, the marginal product is (positive, negative, zero) \_\_\_\_\_, but if it decreases, the marginal product is \_\_\_\_\_.
8. If the marginal product of any input exceeds its average product, the average product is (rising, falling) \_\_\_\_\_, but if it is less than its average product, the average product is \_\_\_\_\_. If the marginal product is equal to its average product, the average product is at a (minimum, maximum) \_\_\_\_\_.
9. Those costs that in total do not vary with changes in output are (fixed, variable) \_\_\_\_\_ costs, but those costs that in total change with the level of output are \_\_\_\_\_ costs. The sum of fixed and variable costs at each level of output is (marginal, total) \_\_\_\_\_ cost.
10. The law of diminishing returns explains why a firm's average variable, average total, and marginal cost may at first tend to (increase, decrease) \_\_\_\_\_ but ultimately \_\_\_\_\_ as the output of the firm increases.
11. Marginal cost is the increase in (average, total) \_\_\_\_\_ variable cost or \_\_\_\_\_ cost that occurs when the firm increases its output by one unit.
12. If marginal cost is less than average variable cost, average variable cost will be (rising, falling, constant) \_\_\_\_\_ but if average variable cost is less than marginal cost, average variable cost will be \_\_\_\_\_.
13. Assume that labor is the only variable input in the short run and that the wage rate paid to labor is constant.
- When the marginal product of labor is rising, the marginal cost of producing a product is (rising, falling) \_\_\_\_\_.
  - When the average variable cost of producing a product is falling, the average product of labor is (rising, falling) \_\_\_\_\_.
  - At the output at which marginal cost is at a minimum, the marginal product of labor is at a (minimum, maximum) \_\_\_\_\_.
  - At the output at which the average product of labor is at a maximum, the average variable cost of producing the product is at a (minimum, maximum) \_\_\_\_\_.
  - At the output at which the average variable cost is at a minimum, average variable cost and (marginal, total) \_\_\_\_\_ cost are equal and average product and \_\_\_\_\_ product are equal.
14. Changes in either resource prices or technology will cause cost curves to (shift, remain unchanged) \_\_\_\_\_. If average fixed costs increase, then the average fixed costs curve will (shift up, shift down, remain unchanged) \_\_\_\_\_ and the average total cost curve will \_\_\_\_\_, but the average variable cost curve will \_\_\_\_\_ and the marginal cost curve will (shift up, shift down, remain unchanged) \_\_\_\_\_.
15. If average variable costs increase, then the average variable cost curve will (shift up, shift down, remain unchanged) \_\_\_\_\_ and the average total cost curve will \_\_\_\_\_, and the marginal cost curve will (shift up, shift down, remain unchanged) \_\_\_\_\_, but the average fixed cost curve would \_\_\_\_\_.
16. The short-run costs of a firm are fixed and variable costs, but in the long run all costs are (fixed, variable) \_\_\_\_\_. The long-run average total cost of producing a product is equal to the lowest of the short-run costs of producing that product after the firm has had all the time it requires to make the appropriate adjustments in the size of its (workforce, plant) \_\_\_\_\_.
17. List the three important sources of economies of scale:
- \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_
18. When the firm experiences diseconomies of scale, it has (higher, lower) \_\_\_\_\_ average total costs as \_\_\_\_\_.

output increases. Where diseconomies of scale are operative, an increase in all inputs will cause a (greater, less)

\_\_\_\_\_than-proportionate increase in output.

The factor that gives rise to large diseconomies of scale

\_\_\_\_\_ managerial (specialization, difficulties) \_\_\_\_\_.

19. The smallest level of output at which a firm can minimize long-run average costs is (maximum, minimum)

\_\_\_\_\_ efficient scale. Relatively large and small firms could coexist in an industry and be equally viable when there is an extended range of (increasing, decreasing, constant) \_\_\_\_\_ returns to scale.

20. In some industries, the long-run average cost curve will (increase, decrease) \_\_\_\_\_ over a long range of output and efficient production will be achieved with only

a few (small, large) \_\_\_\_\_ firms. The conditions for a natural monopoly are created when (economies, diseconomies) \_\_\_\_\_ of scale extend beyond the market's size so that unit costs are minimized by having a single firm produce a product.

#### ■ TRUE-FALSE QUESTIONS

Circle T if the statement is true, F if it is false.

1. The economic costs of a firm are the payments it must make to resource owners to attract their resources from alternative employments. **T F**
2. Economic or pure profit is an explicit cost, while normal profit is an implicit cost. **T F**
3. In the short run the size (or capacity) of a firm's plant is fixed. **T F**
4. The resources employed by a firm are all variable in the long run and all fixed in the short run. **T F**
5. The law of diminishing returns states that as successive amounts of a variable resource are added to a fixed resource, beyond some point total output will diminish. **T F**
6. An assumption of the law of diminishing returns is that all units of variable inputs are of equal quality. **T F**
7. When total product is increasing at a decreasing rate, marginal product is positive and increasing. **T F**
8. When average product is falling, marginal product is greater than average product. **T F**

When marginal product is negative, total production (output) is decreasing. **T F**

The larger the output of a firm, the smaller the fixed cost of the firm. **T F**

The law of diminishing returns explains why increases in variable costs associated with each 1-unit increase

in output become greater and greater after a certain point. **T F**

12. Fixed costs can be controlled or altered in the short run. **T F**

13. Total cost is the sum of fixed and variable costs at each level of output. **T F**

14. Marginal cost is the change in fixed cost divided by the change in output. **T F**

15. The marginal cost curve intersects the average total cost (ATC) curve at the ATC curve's minimum point. **T F**

16. If the fixed cost of a firm increases from one year to the next (because the premium it must pay for the insurance on the buildings it owns has been increased) while its variable cost schedule remains unchanged, its marginal cost schedule will also remain unchanged. **T F**

17. Marginal cost is equal to average variable cost at the output at which average variable cost is at a minimum. **T F**

18. When the marginal product of a variable resource increases, the marginal cost of producing the product will decrease, and when marginal product decreases, marginal cost will increase. **T F**

19. If the price of a variable input should increase, the average variable cost, average total cost, and marginal cost curves would all shift upward, but the position of the average fixed cost curve would remain unchanged. **T F**

20. One explanation why the long-run average total cost curve of a firm rises after some level of output has been reached is the law of diminishing returns. **T F**

21. If a firm increases all its inputs by 20% and its output increases by 30%, the firm is experiencing economies of scale. **T F**

22. The primary cause of diseconomies of scale is increased specialization of labor. **T F**

23. If a firm has constant returns to scale in the long run, the total cost of producing its product does not change when it expands or contracts its output. **T F**

24. Minimum efficient scale occurs at the largest level of output at which a firm can minimize long-run average costs. **T F**

25. The fundamental reason that newspapers have such low prices is the low production costs from economies of scale. **T F**

#### ■ MULTIPLE-CHOICE QUESTIONS

Circle the letter that corresponds to the best answer.

1. Suppose that a firm produces 100,000 units a year and sells them all for \$5 each. The explicit costs of

production are \$350,000 and the implicit costs of production are \$100,000. The firm has an accounting profit of

- (a) \$200,000 and an economic profit of \$25,000
- (b) \$150,000 and an economic profit of \$50,000
- (c) \$125,000 and an economic profit of \$75,000
- (d) \$100,000 and an economic profit of \$50,000

2. Economic profit for a firm is defined as the total revenue of the firm minus its

- (a) accounting profit
- (b) normal profit
- (c) implicit costs
- (d) economic cost

3. Which would best describe the short run for a firm as defined by economists?

- (a) The plant capacity for a firm is variable.
- (b) The plant capacity for a firm is fixed.
- (c) There are diseconomies of scale.
- (d) There are economies of scale.

4. Which is most likely to be a long-run adjustment for a firm that manufactures golf carts on an assembly line basis?

- (a) an increase in the amount of steel the firm buys
- (b) a reduction in the number of shifts of workers from three to two
- (c) a change in the production managers of the assembly line
- (d) a change from the production of golf carts to motorcycles

5. The change in total product divided by the change in resource input defines

- (a) total cost
- (b) average cost
- (c) average product
- (d) marginal product

Use the following table to answer Questions 6 and 7. Assume that the only variable resource used to produce output is labor.

Amount of labor	Amount of output
1	3
2	8
3	12
4	15
5	17
6	18

6. The marginal product of the fourth unit of labor is

- (a) 2 units of output
- (b) 3 units of output
- (c) 4 units of output
- (d) 15 units of output

7. When the firm hires four units of labor the average product of labor is

- (a) 3 units of output
- (b) 3.75 units of output
- (c) 4.25 units of output
- (d) 15 units of output

8. Because the marginal product of a variable resource initially increases and later decreases as a firm increases its output,

- (a) average variable cost decreases at first and then increases
- (b) average fixed cost declines as the output of the firm expands
- (c) variable cost at first increases by increasing amounts and then increases by decreasing amounts
- (d) marginal cost at first increases and then decreases

9. Because the marginal product of a resource at first increases and then decreases as the output of the firm increases,

- (a) average fixed cost declines as the output of the firm increases
- (b) average variable cost at first increases and then decreases
- (c) variable cost at first increases by increasing amounts and then increases by decreasing amounts
- (d) total cost at first increases by decreasing amounts and then increases by increasing amounts

For Questions 10, 11, and 12, use the data given in the following table. The fixed cost of the firm is \$500, and the firm's total variable cost is indicated in the table.

Output	Total variable cost
1	\$ 200
2	360
3	500
4	700
5	1000
6	1800

10. The average variable cost of the firm when 4 units of output are produced is

- (a) \$175
- (b) \$200
- (c) \$300
- (d) \$700

11. The average total cost of the firm when 4 units of output are being produced is

- (a) \$175
- (b) \$200
- (c) \$300
- (d) \$700

12. The marginal cost of the sixth unit of output is

- (a) \$200
- (b) \$300
- (c) \$700
- (d) \$800

13. Marginal cost and average variable cost are equal at the output at which

- (a) marginal cost is a minimum
- (b) marginal product is a maximum
- (c) average product is a maximum
- (d) average variable cost is a maximum

14. Average variable cost may be either increasing or decreasing when

- (a) marginal cost is decreasing
- (b) marginal product is increasing
- (c) average fixed cost is decreasing
- (d) average total cost is increasing

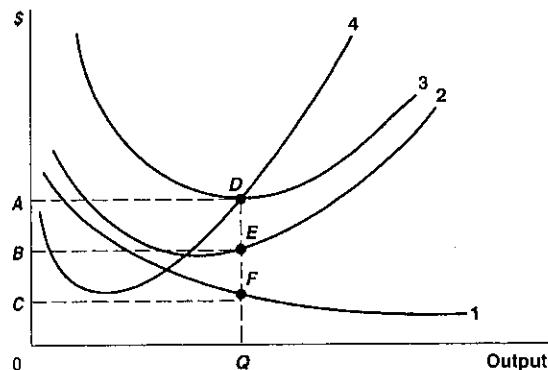
15. Why does the short-run marginal cost curve eventually increase for the typical firm?

- (a) diseconomies of scale
- (b) minimum efficient scale
- (c) the law of diminishing returns
- (d) economic profit eventually decreases

16. If the price of labor or some other variable resource increased, the

- (a) AVC curve would shift downward
- (b) AFC curve would shift upward
- (c) AFC curve would shift downward
- (d) MC curve would shift upward

Questions 17, 18, 19, and 20 are based on the following figure.



17. In the figure, curves 1, 3, and 4, respectively, represent

- (a) average variable cost, marginal cost, and average total cost
- (b) average total cost, average variable cost, and marginal cost
- (c) average fixed cost, average total cost, and marginal cost
- (d) marginal cost, average total cost, and average variable cost

18. At output level  $Q$ , the average fixed cost is measured by the vertical distance represented by

- (a)  $DE$
- (b)  $DF$
- (c)  $DQ$
- (d)  $EF$

19. As output increases beyond the level represented by  $Q$ ,

- (a) marginal product is rising
- (b) marginal product is falling

- (c) total fixed costs are rising
- (d) total costs are falling

20. If the firm is producing at output level  $Q$ , then the total variable costs of production are represented by area

- (a)  $OQFC$
- (b)  $OQEB$
- (c)  $OQDC$
- (d)  $CFEB$

21. At an output of 10,000 units per year, a firm's total variable costs are \$50,000 and its average fixed costs are

\$2. The total costs per year for the firm are

- (a) \$50,000
- (b) \$60,000
- (c) \$70,000
- (d) \$80,000

22. A firm has total fixed costs of \$4,000 a year. The average variable cost is \$3.00 for 2000 units of output. At this level of output, its average total costs are

- (a) \$2.50
- (b) \$3.00
- (c) \$4.50
- (d) \$5.00

23. If you know that total fixed cost is \$100, total variable cost is \$300, and total product is 4 units, then

- (a) marginal cost is \$50
- (b) average fixed cost is \$45
- (c) average total cost is \$125
- (d) average variable cost is \$75

24. If the short-run average variable costs of production for a firm are falling, then this indicates that

- (a) average variable costs are above average fixed costs
- (b) marginal costs are below average variable costs
- (c) average fixed costs are constant
- (d) total costs are falling

Answer Questions 25 and 26 using the following table. Three short-run cost schedules are given for three plants of different sizes that a firm might build in the long run.

Plant 1		Plant 2		Plant 3	
Output	ATC	Output	ATC	Output	ATC
10	\$10	10	\$15	10	\$20
20	9	20	10	20	15
30	8	30	7	30	10
40	9	40	10	40	8
50	10	50	14	50	9

25. What is the long-run average cost of producing 40 units of output?

- (a) \$7
- (b) \$8
- (c) \$9
- (d) \$10

26. At what output is long-run average cost at a minimum?

- (a) 20
- (b) 30
- (c) 40
- (d) 50

27. If the long-run average total cost curve for a firm is downsloping, then it indicates that there

- (a) is a minimum efficient scale
- (b) are constant returns to scale
- (c) are diseconomies of scale
- (d) are economies of scale

28. Which factor contributes to economies of scale?

- (a) less efficient use of capital goods
- (b) less division of labor and specialization
- (c) greater specialization in management of a firm
- (d) greater difficulty controlling the operations of a firm

29. A firm is encountering constant returns to scale when it increases all of its inputs by 20% and its output increases by

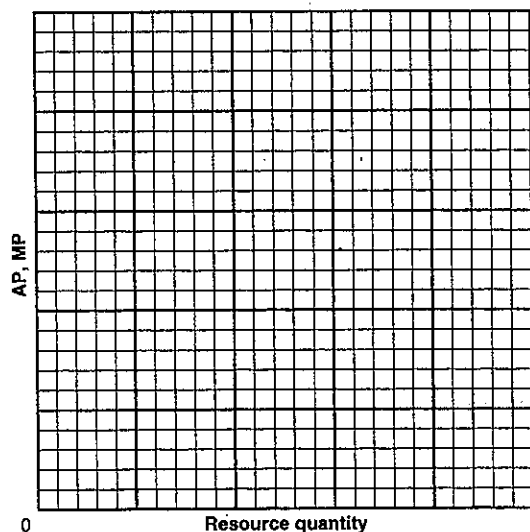
- (a) 10%
- (b) 15%
- (c) 20%
- (d) 25%

30. If economies of scale are limited and diseconomies appear quickly in an industry, then minimum efficient scale occurs at a

- (a) high level of output, and there will be a few firms
- (b) high level of output, and there will be many firms
- (c) low level of output, and there will be few firms
- (d) low level of output, and there will be many firms

### PROBLEMS

1. On the following graph, sketch the way in which the average product and the marginal product of a resource change as the firm increases its employment of that resource.



2. The table shows the total production of a firm as the quantity of labor employed increases. The quantities of all other resources employed remain constant.

a. Compute the marginal products of the first through the eighth units of labor and enter them in the table.

Units of labor	Total production	Marginal product of labor	Average product of labor
0	0		0
1	80		
2	200		
3	330		
4	400		
5	450		
6	480		
7	490		
8	480		

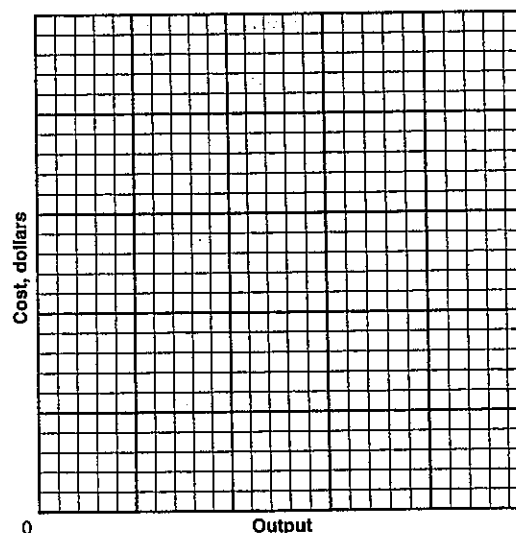
b. Now compute the average products of the various quantities of labor and enter them in the table.

c. There are increasing returns to labor from the first through the \_\_\_\_\_ units of labor and decreasing returns from the \_\_\_\_\_ through the eighth units.

d. When total production is increasing, marginal product is (positive, negative) \_\_\_\_\_ and when total production is decreasing, marginal product is \_\_\_\_\_.

e. When marginal product is greater than average product, then average product will (rise, fall) \_\_\_\_\_, and when marginal product is less than average product, the average product will \_\_\_\_\_.

3. On the graph below sketch the manner in which fixed cost, variable cost, and total cost change as the output the firm produces in the short run changes.





Quantity of labor employed	Total output	Marginal product of labor	Average product of labor	Total cost	Marginal cost	Average variable cost
0	0	—	—	\$	—	—
1	5	5	5		\$	\$
2	11	6	5.50			
3	18	7	6			
4	24	6	6			
5	29	5	5.80			
6	33	4	5.50			
7	36	3	5.14			
8	38	2	4.75			
9	39	1	4.33			
10	39	0	3.90			

4. Assume that a firm has a plant of fixed size and that it can vary its output only by varying the amount of labor it employs. The table at the top of the page shows the relationships among the amount of labor employed, the output of the firm, the marginal product of labor, and the average product of labor.

a. Assume each unit of labor costs the firm \$10. Compute the total cost of labor for each quantity of labor the firm might employ, and enter these figures in the table.

b. Now determine the marginal cost of the firm's product as the firm increases its output. Divide the increase in total labor cost by the *increase* in total output to find the marginal cost. Enter these figures in the table.

c. When the marginal product of labor

(1) increases, the marginal cost of the firm's product (increases, decreases) \_\_\_\_\_.

(2) decreases, the marginal cost of the firm's product \_\_\_\_\_.

d. If labor is the only variable input, the total labor cost and total variable cost are equal. Find the average variable cost of the firm's product (by dividing the total labor cost by total output) and enter these figures in the table.

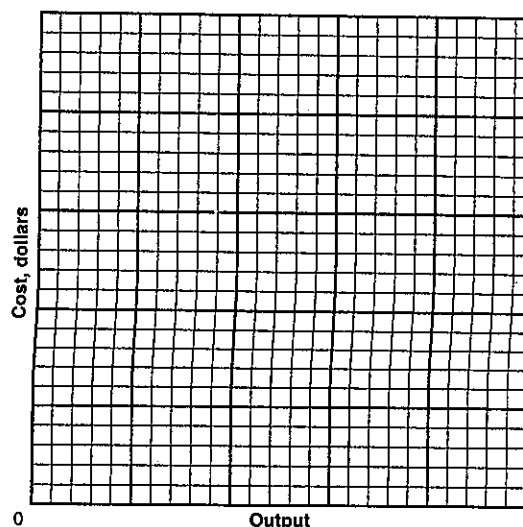
e. When the average product of labor

(1) increases, the average variable cost (increases, decreases) \_\_\_\_\_.

(2) decreases, the average variable cost \_\_\_\_\_.

5. The law of diminishing returns causes a firm's average variable, average total, and marginal cost to decrease at first and then to increase as the output of the firm increases.

Sketch these three cost curves on the following graph in such a way that their proper relationship to each other is shown.



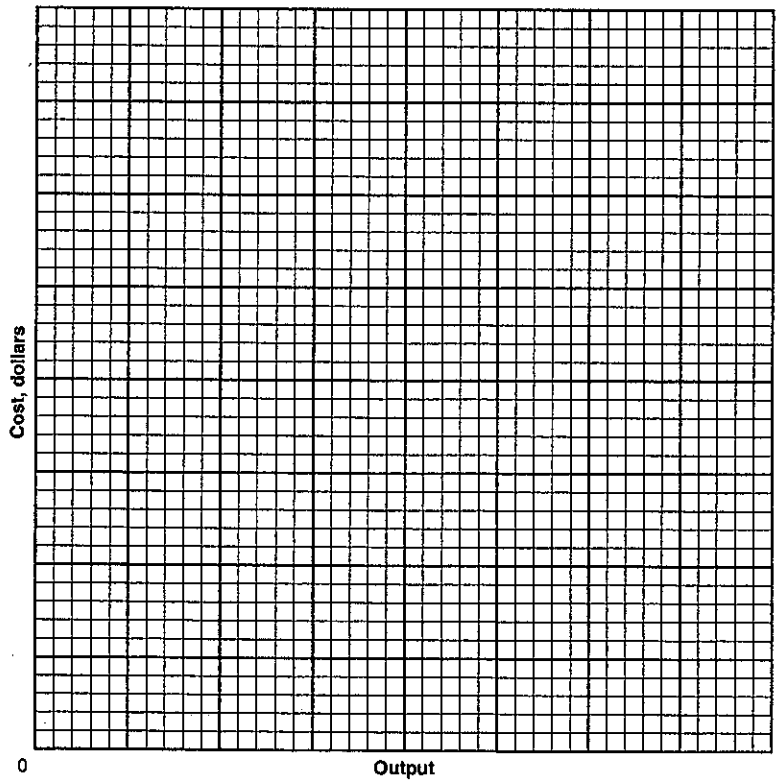
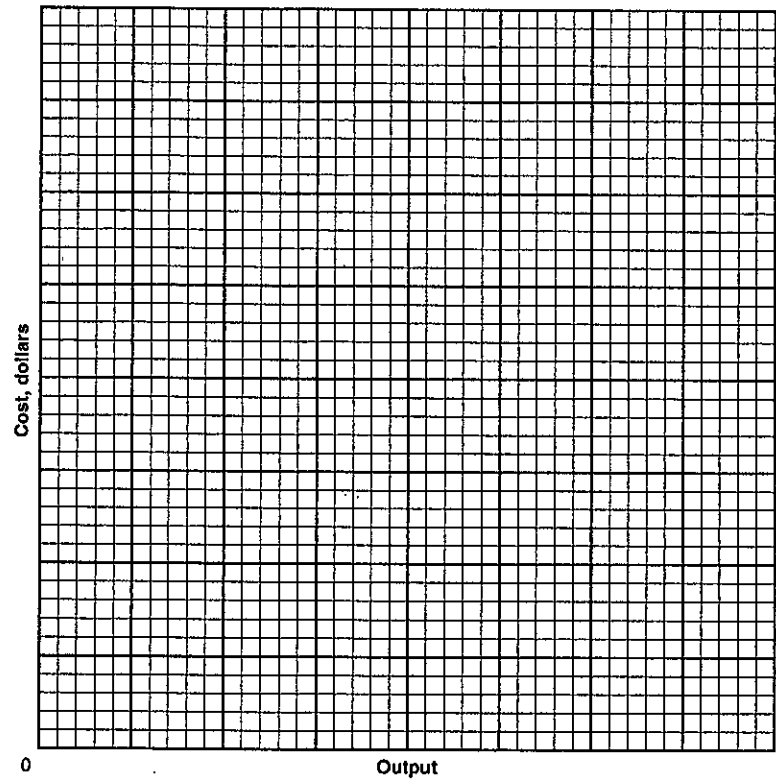
6. The table that follows is a schedule of a firm's fixed cost and variable cost.

a. Complete the table by computing total cost, average fixed cost, average total cost, and marginal cost.

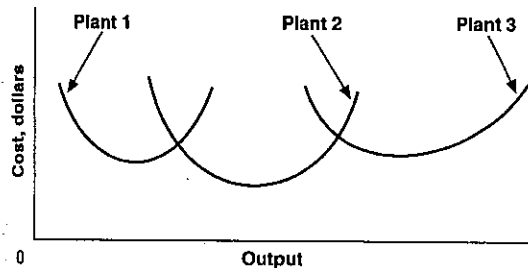
b. On the graph at the top of the next page, plot and label fixed cost, variable cost, and total cost.

c. On the graph at the bottom of the next page, plot average fixed cost, average variable cost, average total cost, and marginal cost. Label the four curves.

Output	Total fixed cost	Total variable cost	Total cost	Average fixed cost	Average variable cost	Average total cost	Marginal cost
0	\$200	\$ 0	\$				
1	200	50		\$	\$50.00	\$	\$
2	200	90			45.00		
3	200	120			40.00		
4	200	160			40.00		
5	200	220			44.00		
6	200	300			50.00		
7	200	400			57.14		
8	200	520			65.00		
9	200	670			74.44		
10	200	900			90.00		



7. Following are the short-run average cost curves of producing a product with three different sizes of plants, Plant 1, Plant 2, and Plant 3. Draw the firm's long-run average cost on this graph.



8. Following are the short-run average total cost schedules for three plants of different sizes that a firm might build to produce its product. Assume that these are the only possible sizes of plants that the firm might build.

Plant size A		Plant size B		Plant size C	
Output	ATC	Output	ATC	Output	ATC
10	\$ 7	10	\$17	10	\$53
20	6	20	13	20	44
30	5	30	9	30	35
40	4	40	6	40	27
50	5	50	4	50	20
60	7	60	3	60	14
70	10	70	4	70	11
80	14	80	5	80	8
90	19	90	7	90	6
100	25	100	10	100	5
110	32	110	16	110	7
120	40	120	25	120	10

a. Complete the long-run average cost schedule for the firm in the following table.

Output	Average cost	Output	Average cost
70	\$ _____	70	\$ _____
80	_____	80	_____
90	_____	90	_____
100	_____	100	_____
110	_____	110	_____
120	_____	120	_____

b. For outputs between

(1) \_\_\_\_\_ and \_\_\_\_\_, the firm should build Plant A.

(2) \_\_\_\_\_ and \_\_\_\_\_, the firm should build Plant B.

(3) \_\_\_\_\_ and \_\_\_\_\_, the firm should build Plant C.

### ■ SHORT ANSWER AND ESSAY QUESTIONS

1. Explain the meaning of the opportunity cost of producing a product and the difference between an explicit cost and an implicit cost. How would you determine the implicit money cost of a resource?

2. What is the difference between normal profit and economic profit? Why is the former an economic cost? How do you define accounting profit?

3. What type of adjustments can a firm make in the long run that it cannot make in the short run? What adjustments can it make in the short run? How long is the short run?

4. Why is the distinction between the short run and the long run important?

5. State precisely the law of diminishing returns. Exactly what is it that diminishes, and why does it diminish?

6. Distinguish between a fixed cost and a variable cost.

7. Why are short-run total costs partly fixed and partly variable costs, and why are long-run costs entirely variable?

8. Why do short-run variable costs increase at first by decreasing amounts and later increase by increasing amounts?

9. How does the behavior of short-run variable costs influence the behavior of short-run total costs?

10. Describe the way in which short-run average fixed cost, average variable cost, average total cost, and marginal cost vary as the output of the firm increases.

11. What are the connections between marginal product and marginal cost, and between average product and average variable cost? How will marginal cost behave as marginal product decreases and increases? How will average variable cost change as average product rises and falls?

12. What are the precise relationships between marginal cost and minimum average variable cost, and between marginal cost and minimum average total cost? Why are these relationships necessarily true?

13. What happens to the average total cost, average variable cost, average fixed cost, and marginal cost curves when the price of a variable input increases or decreases? Describe what other factor can cause short-run cost curves to shift.

14. What does the long-run average cost curve of a firm show? What relationship is there between long-run average cost and the short-run average total cost schedules of the different-sized plants which a firm might build?

15. Why is the long-run average cost curve of a firm U-shaped?

16. What is meant by economies of scale and by diseconomies of scale?

17. What are factors that contribute to economies of scale?

18. What causes diseconomies of scale?

19. What is minimum efficient scale? How can this concept, combined with economies and diseconomies of scale, be used to describe the number and size of firms in an industry?

20. Describe real examples of short-run costs, economies of scale, and minimum efficient scale.

## ANSWERS

### Chapter 8 The Costs of Production

#### FILL-IN QUESTIONS

1. opportunity
2. resource suppliers, explicit, implicit
3. entrepreneurs, explicit, revenues, costs
4. variable, fixed, short, long
5. variable, fixed, marginal, equal
6. rising, positive, falling
7. zero, negative
8. rising, falling, maximum
9. fixed, variable, total
10. decrease, increase
11. total, total
12. falling, rising
13. a. falling; b. rising; c. maximum; d. minimum; e. marginal, marginal
14. shift, shift up, shift up, remain unchanged, remain unchanged
15. shift up, shift up, shift up, remain unchanged
16. variable, plant
17. a. labor specialization; b. managerial specialization; c. more efficient use
18. higher, less, difficulties
19. minimum, constant
20. decrease, large, economies

#### TRUE-FALSE QUESTIONS

- |                   |                    |                    |
|-------------------|--------------------|--------------------|
| 1. T, p. 155      | 10. F, p. 159      | 19. T, p. 165      |
| 2. F, pp. 155–156 | 11. T, p. 161      | 20. F, pp. 166–167 |
| 3. T, p. 156      | 12. F, p. 159      | 21. T, pp. 168–169 |
| 4. F, p. 156      | 13. T, p. 161      | 22. F, p. 169      |
| 5. F, pp. 157–158 | 14. F, p. 163      | 23. F, p. 170      |
| 6. T, pp. 157–158 | 15. T, pp. 164–165 | 24. F, p. 170      |
| 7. F, pp. 159–160 | 16. T, p. 163      | 25. T, p. 171      |
| 8. F, pp. 159–160 | 17. T, pp. 164–165 |                    |
| 9. T, pp. 159–160 | 18. T, pp. 163–164 |                    |

#### MULTIPLE-CHOICE QUESTIONS

- |                    |                    |                    |
|--------------------|--------------------|--------------------|
| 1. b, p. 155       | 11. c, p. 163      | 21. c, pp. 162–163 |
| 2. d, p. 156       | 12. d, p. 163      | 22. d, pp. 162–163 |
| 3. b, p. 156       | 13. c, pp. 163–165 | 23. d, pp. 162–163 |
| 4. d, p. 156       | 14. c, pp. 163–165 | 24. b, pp. 163–165 |
| 5. d, p. 157       | 15. c, pp. 163–164 | 25. b, pp. 166–167 |
| 6. b, p. 157       | 16. d, pp. 164–165 | 26. b, pp. 166–167 |
| 7. b, p. 157       | 17. c, p. 164      | 27. d, pp. 167–168 |
| 8. a, pp. 163–165  | 18. a, p. 164      | 28. c, pp. 168–169 |
| 9. d, pp. 163–165  | 19. b, p. 164      | 29. c, p. 170      |
| 10. a, pp. 162–163 | 20. b, p. 164      | 30. d, p. 170      |

#### PROBLEMS

1. see Figure 8.2(b) of the text
2. a. 80, 120, 130, 70, 50, 30, 10, -10; b. 80, 100, 110, 100, 90, 80, 70, 60; c. third, fourth; d. positive, negative; e. rise, fall
3. see Figure 8.3 of the text
4. a. \$0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100; b. \$2.00, 1.67, 1.43, 1.67, 2.00, 2.50, 3.33, 5.00, 1.00, NA; c. (1) decreases, (2) increases; d. 2.00, 1.82, 1.67, 1.67, 1.72, 1.82, 1.94, 2.11, 2.31, 2.56; e. (1) decreases, (2) increases
5. see Figure 8.5 of the text
6. a. see table below; b. graph; c. graph

Total cost	Average fixed cost	Average total cost	Marginal cost
\$ 200	—	—	—
250	\$200.00	\$250.00	\$ 50
290	100.00	145.00	40
320	66.67	106.67	30
360	50.00	90.00	40
420	40.00	84.00	60
500	33.33	83.33	80
600	28.57	85.71	100
720	25.00	90.00	120
870	22.22	96.67	150
1100	20.00	110.00	230

7. see Figures 8.7 and 8.8 of the text
8. a. \$7.00, 6.00, 5.00, 4.00, 4.00, 3.00, 4.00, 5.00, 6.00, 5.00, 7.00, 10.00; b. (1) 10, 40, (2) 50, 80, (3) 90, 120

#### SHORT ANSWER AND ESSAY QUESTIONS

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|----------------|-----------------|-----------------|
| 1. p. 155      | 8. p. 161       | 15. pp. 167–168 |
| 2. pp. 155–156 | 9. pp. 161–162  | 16. pp. 167–169 |
| 3. p. 156      | 10. pp. 162–165 | 17. pp. 168–169 |
| 4. p. 156      | 11. pp. 163–165 | 18. p. 169      |
| 5. pp. 157–158 | 12. pp. 163–165 | 19. p. 170      |
| 6. pp. 159–161 | 13. p. 165      | 20. pp. 170–171 |
| 7. pp. 161–162 | 14. pp. 166–167 |                 |